Self-contained self-rescuer legislation within the context of the Mine Health and Safety Act of South Africa: a critical analysis

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1. Introduction

Ever since their introduction following legislation in 1986, self-contained self-rescuers (SCSRs) have been the subject of intense debate, if not controversy. The most recent and obvious example is that the promulgation of regulations on SCSRs (Government Gazette No 23410 of 17 May 2002), specifically Regulation 16.2(3) of the Mine Health and Safety Act (MHSAct), effectively rules out 'multishifting' of SCSRs because of its insistence on 'sole use'. (Multishifting implies that the same SCSRs are randomly re-issued on consecutive daily underground shifts.)

To restrict the debate to the pros and cons of multishifting of SCSRs is oversimplistic and even misleading. The purpose of this review is, therefore, to also consider related, but often inapparent, factors that have had a bearing on SCSR legislation in the South African mining industry. Over recent years there has been a decided international swing towards chemical-based oxygen SCSRs and it is suggested that many of the considerations presented in this paper are not irrelevant to other mining countries.

2. Status of SCSR monitoring in the South African mining industry

In 2002, about 84 000 SCSRs were deployed in South African mines, the overwhelming majority being distributed between gold (43%), coal (33%), platinum (13%) and diamond (6%) mines. The major suppliers (or original equipment manufacturers; OEMs) are Draeger (Oxyboks K), MSA (MSA/AUER SSR 30) and Afrox (Afrox Pac).

SCSRs are subjected to a comprehensive Industry-wide monitoring programme, as outlined in Figure 1. The fundamental purpose is to ensure that their functional performance (or life-saving capacity) is not compromised. In this respect, the CSIR's Division of Mining Technology (Miningtek) has been appointed by the Department of Minerals and Energy (DME) as the Approved Testing Authority (ATA) in terms of the requirements specified by the South African National Accreditation System. The ATA reports to the 'Tripartite Technical Committee (TTC) on SCSRs', the term 'tripartite' referring to the link created between the State (DME) and representation of, respectively, the mining industry and organized labour. The TTC's primary responsibility is the safety of underground employees and its function can be best likened to an industry 'watchdog'.

Under Regulation 16.4(1) of the MHSAct, the ATA draws a 'representative' sample of SCSRs of not less than 1% from each mine on an annual basis. These units are subjected to a battery of tests, including functional performance. Where untoward trends become apparent, more units of the same batch, service history, etc. are drawn and tested to confirm (or

otherwise) earlier results and findings. Depending on the nature of the findings, mines can be alerted immediately. Equally, in the event of, for example, poor quality control or component failure, suppliers would also be informed so that, in collaboration with affected mines, contingency and longer term plans can be prioritized.

Since the integrity of SCSR performance is a function also of the level of 'duty of care' exercised by mines, the monitoring programme includes an assessment of the competency of mines' infrastructures. For this purpose a rating system is used. As a direct result of ongoing feedback to mines, in conjunction with quarterly and annual reviews, trends over recent years reflect consistent improvements. At present, more than 90% of mines exhibit 'acceptable compliance' with minimum requirements. (Schreiber and Kielblock, 2003).

Every year SCSRs are being used in underground emergencies and analyses of incidents leading to SCSR activation confirm that numerous underground employees owe their lives to functional SCSRs (Kriel et al 1995; Schreiber and Unsted, 1999). In two instances SCSR failure were recorded but, fortunately, not associated with fatalities. Therefore, although the SCSR monitoring is fundamentally important, the extent to which lives are saved (or lost) depends substantially also on appropriate warning systems, emergency response training and back-up systems, notably refuge bays. These elements form part of a mine-specific escape rescue strategy, a direct responsibility of the employer, as shown in Figure 1. It should be evident, therefore, that ultimately the protection and safety of employees must be based on a rather fragile 'partnership' between the TTC and the employer.

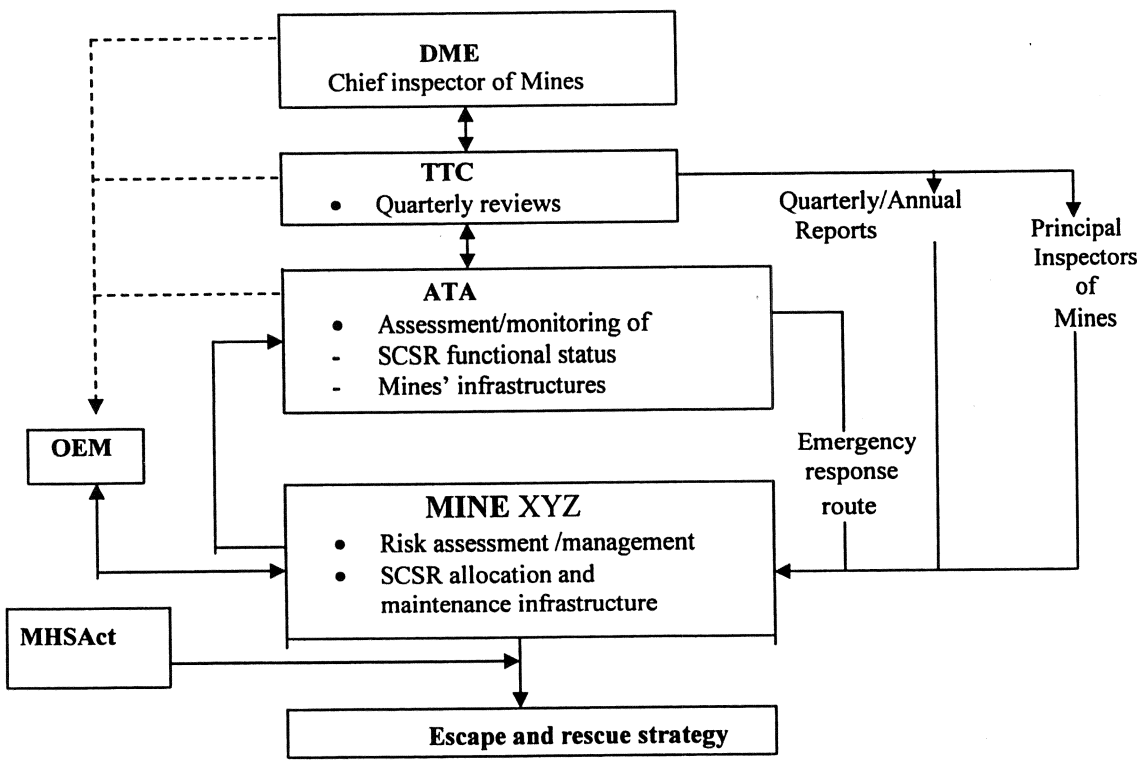


Figure 1: Main elements and communication lines relevant to SCSR monitoring

3. SCSRs in perspective

Unlike many other pieces of safety equipment, the functional or life-saving capacity of chemically-bound oxygen SCSRs cannot be assessed readily, for example by means of a convenient gauge, as would be the case with compressed oxygen SCSRs. This is significant because the vast majority of SCSRs deployed locally falls into the former category. (Moisture indicators are generally too insensitive to be reliable in this context.)

Although visual inspections by trained personnel, in conjunction with leak tests, provide some measure of confidence, the acid test remains functional performance assessments by means of a breathing simulator. Quite obviously, this is a destructive test and the most important measure or predictor of SCSR performance is the integrity of the database derived in this fashion. The corollary is equally obvious: to compromise the database is tantamount to compromising, ultimately, confidence in the life-saving capacity of SCSRs.

During 2002, the distribution of the major SCSRs tested by trade name (Schreiber and Kielblock, 2003) were

AfroxPac (30 and 35)	: 303
Draeger Oxyboks (Mk 2)	: 227
MSA/Auer SSR 30/100 (Mk 1 and 2)	: 327

Although comprising only 1% of SCSRs deployed by South African mines, it should be evident that the actual numbers tested in total or by trade name are sufficiently substantial to provide a rather robust database which, if needed, can be strengthened at any time (see Section 2). However, this can only be achieved cost-effectively through a centralised system supported by the entire mining industry. To achieve the same level of confidence by means of a fragmented approach is possible in theory but the costs to individual mines would be exorbitant.

4. Legislation

The MHSAct (Act 29 0f 1996) is generally regarded as an excellent example of modern industrial legislation. One of the features that sets it apart from its predecessors is the non-prescriptive nature of the various sections and regulations, with the focus now falling on 'outcomes'. This gives recognition to the fact that many health and safety issues are mine-specific.

Against this background, it is hardly surprising that considerable opposition was levelled at, mainly, what was to become Regulation 16.2(3), the offending phrase being that SCSRs be allocated to employees '- - for that employee's sole use - - -'. Moreover, apart from its prescriptive nature, which was already in conflict with tripartite agreed principles, Regulation 16.2(3) effectively ruled out 'multishifting' of SCSRs, a practice followed by quite a number of mines at the time, i.e. ten in 2000 and 2001, and seven in 2002.

Technically, and in isolation, the above argument was sound but it did not take into account perhaps the most important requirement of all, namely the employer's responsibility to ensure that defective SCSRs are not issued to employees. It so happens that this regulation, i.e. Regulation 16.3(1), is not prescriptive at all.

A comparison of the main features of the original and the current legislation on SCSRs is given in Table 1. Although a detailed discussion of each falls outside the scope of this paper, the new regulations incorporate and reflect the South African mining industry's experience of close on two decades and, as such, represent a vast but often unrecognised improvement in all respects.

Table 1: Evolution of SCSR regulations

Feature	Minerals Act Regulations 24.201-4 31 October 1986	MHSAct Regulations 16.2 – 4 17 May 2002
Deployment	All, employers irrespective of operation	Coal : All employers Other : risk-based
Operational status	'ready for instant use'	'not defective'
Approval/compliance	GME	SANS1737
Allocation	Not specified	Personal and sole use
Attachment	Body-worn at all times	Body-worn
Duty	30 min at 30 l/min	Rated by SANS 1737
Capacity	Sufficient to reach safety	Not specified; implied
Place of safety	Specified	Not specified
Training	Specified	SANS 1737 evaluation
SCSR monitoring	Not required	Mandatory participation
Records	Not required	Specified
COP	Specified	Not required

Applying an 'outcomes-based' principle, it is clear that the new regulations are prescriptive not only with respect to 'sole use', but also to mandatory participation in a monitoring programme (Regulation 16.4(1)) and record keeping (Regulation 16.4(2)). However, to cite tripartite agreed principles in isolation is, once again, inappropriate.

If the point of departure is regulation 16.3(1), i.e. the all-important requirement that SCSRs issued may not be defective, it follows that in practice the only viable option available to the employer is reliance on the integrity of the central database. (Details appear in Section 2.) In turn, the strength of the database is determined, firstly, by the level of participation in the monitoring programme and, secondly, the relevance of the information. Therefore, to uphold

the objective of Regulation 16.3(1), it follows that, it must be supported by a process that is entirely unambiguous and uniform. Blind adherence to the principle of 'outcomes' would not have served any useful purpose: there is no way in which the employer will be able to ensure that SCSRs issued are 'not defective' if SCSRs are allocated randomly and multishifted, participation in the monitoring programme is voluntary, and disclosure of SCSR maintenance records (etc) remains optional. Regulations 16.3(2), 16.4(1) and 16.4(2), in order to give substance to 16.3(1), must, therefore, be prescriptive.

An alternative approach, as has been argued, is to replace the prescriptive elements of Regulation 16.2 – 4 with a mine-specific code of practice (COP) based on a guideline issued by the DME. Such an approach would support the principle of non-prescriptive ('outcomes-based') regulations. The DME guidelines, although formal documents, only prescribe minimum standards, the implication being that mines ('employers') would have to translate the guideline into a code of practice (COP) incorporating 'best practice'. In this regard, the employer assumes sole responsibility for allocating SCSRs that are not defective. Issues such as 'sole use', mandatory participation in an Industry-wide monitoring programme and disclosure of records would therefore have no reference in legislation.

At face value, therefore, two distinct scenarios exist, i.e.

- automatic compliance with Regulation 16.3(1) through the TTC avenue but within a prescriptive legislative framework (the status quo), or
- the dubious benefit of 'outcomes-based' legislation with the employer, through a mine-specific COP, shouldering full responsibility for compliance with Regulation 16.3(1) on the basis of 'best practice'.

The latter scenario, although attractive and pragmatic at first glance, is riddled with pitfalls. Firstly, the DME Guidelines in support of mine-specific COPs are drafted on the basis of tripartism with the safety of employees the overriding priority. It is therefore most unlikely that these guidelines would be less prescriptive than current regulations. Relegating the prescriptive elements of current legislation to a lower level of compliance, i.e. the DME Guideline/COP mechanism, represents no more than a somewhat cynical exercise in cosmetics with no real benefits to mines.

Secondly, with employers (mines/mining houses) now assuming full ' ownership' of Regulation 16.3(1), it stand to reason that in such a dispensation there would be no room for external co-ordination and control. The demise of the TTC on SCSRs, as well as the current monitoring programme and central database, is a reality in this scenario. The demise of this programme will also bring about the demise of

- a rapid response feedback to mines not only in the event of disconcerting SCSR performance results, but also in the event of substandard practice and procedure,
- quarterly reviews for the early detection of untoward trends heralding premature SCSR deterioration or failure,
- annual reviews highlighting SCSR status by manufacturer and commodity mined, as well as mines' level of compliance with good housekeeping, and
- independent support structures to deal with suppliers or manufacturers on behalf of individual mines or the mining industry in its entirety.

Thirdly, the TTC is founded on tripartism but, in addition, enjoys a wealth of technical expertise and experience in its membership. Employers, by contrast, could at best claim a degree of bipartism but never at the same levels of transparency or credibility exercised by the TTC. This is a perception that cannot be underestimated, especially when lives are lost in incidents leading to the development of acute, irrespirable atmospheres.

A final consideration is the questionable extent to which mines are capable of establishing and maintaining costly infrastructures on their own to ensure compliance with Regulation 16.3(1), i.e. 'no defective' SCSRs are to be issued to employees. At present, as a direct consequence of the TTC-controlled SCSR monitoring programme, mine standards and infrastructures exhibit a very high level of compliance (Schreiber and Kielblock, 2002).

5. Multishifting

At mine level, the case for multishifting SCSRs on a daily basis has its origins in the perception that there are significant savings in capital outlay. If the rate of SCSR deterioration is in direct proportion to deployment (measured, for example, in shifts), service life would be reduced accordingly and replacement dates brought forward. The 'saving' incurred is therefore, at best, only a short term solution.

Multishifting is likely to compromise daily inspections, as well as record keeping, especially in the event of rapid shift changeovers. It is not unlikely, therefore, that in such a scenario SCSR deterioration may well increase exponentially. At present there is no hard evidence to support such a contention but, equally, the possibility cannot be rejected. In this respect there are warranty issues that may have a further impact.

There are also warranty issues to consider. At present the OEM provides a general warranty period based on SCSRs being deployed on a single shift per day. For a nominal warranty period of six years for SCSRs the warranty period would accordingly have to be reduced to two years to cater for SCSRs multishifted at a rate of three shifts per day. Furthermore, the annual functional performance monitoring of the units would have to be increased in direct proportion, i.e. to three times per year, to monitor the accelerated deterioration in functional performance of units. The nature of maintenance service contracts, as well as the frequency of leak testing, would also have to be adjusted accordingly.

The argument for multishifting, and hence against current legislation (then in draft format), was based on the perceived spin-offs associated with an escalating SCSR turnover rate, i.e. stimulating technology development and implementing such advances more rapidly. In principle, and in isolation, there is decided merit in the argument. The stumbling block, once again, is the extent to which mines (employers) would be able to comply with Regulation 16.3(1). Some considerations in this respect are

- the capacity of mines to establish viable infrastructures to accommodate the logistical challenges of multishifting,
- the capacity of suppliers to provide support services, and
- the capacity of the Approved Testing Authority in meeting the requirements of the DME's industry-based SCSR monitoring programme without further cost escalations.

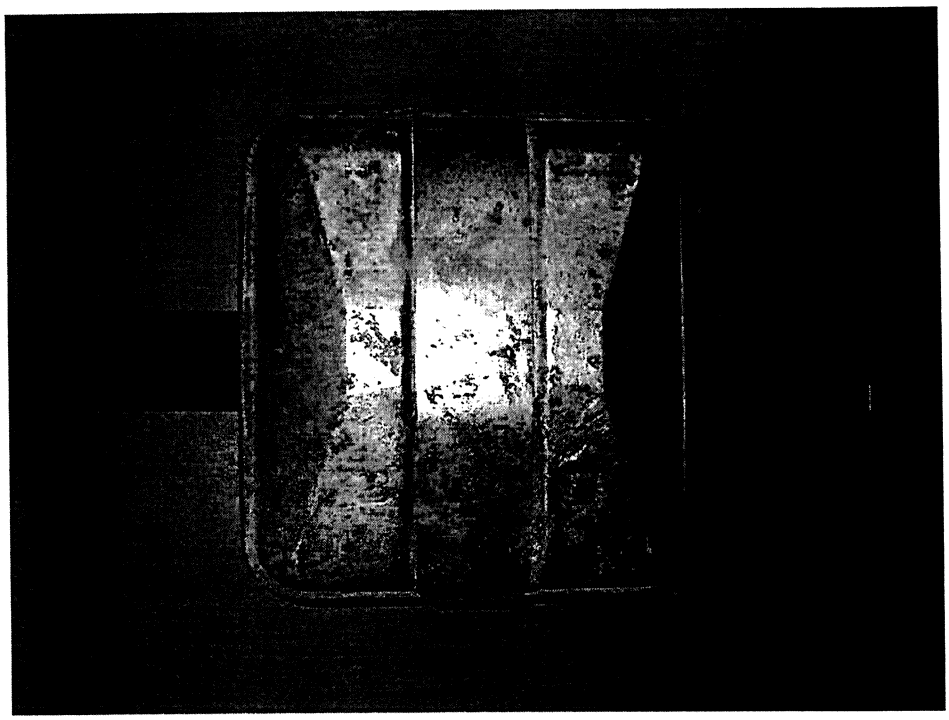
In all of the above challenges, even if feasible in practice, any savings that might have accrued by postponing the purchase of SCSRs actually needed would be eroded by escalating unit maintenance and inspection costs.

Perhaps the most crucial obstacle is that multishifting is unlikely to promote a sense of ownership. There is overwhelming evidence of neglect, abuse and, in instances, blatant vandalism.

From experience gained during the monitoring programme over the last seven years, it was found that the general condition, and specifically the life-saving potential of units being multishifted, deteriorates to an extent that can no longer be predicted. Therefore, no functional performance trends can be established even on an industry-wide basis. This situation could perhaps be addressed by a larger sample of units. This, however, would once again defeat the object of cost savings.

The two examples of SCSRs shown below do not reflect the condition of the inner structures, notably the extensive powderisation of the chemical bed in Example 2. In some instances deterioration amounted to a reduction of more than ten minutes' safe functional duration per year in units subjected to multishifting. This should be viewed against a projected yearly reduction of approximately two to three minutes in functional duration in units allocated on a personal basis.

Example 1: An SCSR allocated on a personal basis for two years.



Example 2: An SCSR multishifted (three shifts per day) for two years.

'Homogenous group' allocation, i.e. the random allocation of SCSRs to employees in the same job category, has been proposed as an alternative to the more prescriptive 'sole use' stipulation. The argument, naïvely based on mathematical probabilities, suggests that by allocating SCSRs to 'homogenous groups', the risk of being allocated a defective SCSR is less because it becomes a 'shared' risk. The extent to which 'spreading of the risk', even on the basis of sound mathematical argument, can be regarded as a counter to willful vandalism and neglect is not only highly questionable, but immoral.

By contrast, the personal allocation of SCSRs ('sole use') is supported by a review of SCSR systems of control and management prevalent in the mining industries of South Africa and the United States of America (MacKenzie-Wood, 2000). The review takes the form of a set of recommendations to the coal mining industries of Queensland and New South Wales, Australia. Recommendations relevant to the above argument are quoted below.

- 'Each person employed to go underground at a colliery is allocated with a SCSR on a **personal** (MacKenzie-Wood's emphasis) basis. This device is not to be shared with any other person or used for any other purpose.'
- 'It must be the responsibility of each person issued with a SCSR to carefully inspect the device on a daily basis, with strict adherence to the manufacturer's recommendations. If in any doubt the SCSR must be returned to the supplier for examination.'

One of the stated objectives of the Mine Health and Safety Act is '- - - to promote a culture of health and safety in the mining industry - - -'. Moreover, Section 22 of the Act outlines employees' duties in respect of maintaining health and safety in no uncertain terms. Willful neglect, abuse and vandalism, some of the key issues in support of the 'sole use' stipulation, are not only in conflict with the objectives of the Act, but also offenses of no uncertain

dimensions. By invoking mathematical probabilities of 'shared risk' as a counter to 'sole use', is nothing short of a rather clumsy attempt to dodge the real issues.

6. Conclusion

The South African mining industry's experience with respect to the introduction of body-worn SCSRs is comprehensive and unique, even on an international scale. Local practice and procedure have often been, not surprisingly, instrumental in establishing precedent in mining industries elsewhere in the world.

A typical example of 'benchmarking' is the local SCSR monitoring programme, first formal report to Industry dating back to 1990 (Celliers et al, 1990). In its current guise, therefore, SCSR monitoring is a product of evolution benefiting from the wealth of nearly two decades' research and development experience.

Current SCSR legislation (Regulation 16.2 – 4) has been opposed on the basis of being prescriptive and in conflict with the tripartite agreed regulatory principle embodying 'outcomes-based' regulations. In general, this principle is not in dispute and, in fact, has much to commend it, especially in fostering 'best practice' at mine level. However, to apply this principle to SCSR legislation without recognizing the idiosyncracies of chemical-based SCSRs, as well as ignoring the lessons of the past, is shortsighted.

The crux of the argument is not complicated. If compressed oxygen SCSRs had been the preferred choice, their state of readiness and functional capacity would have been available instantaneously and at any time, through the simple expedient of an accurate gauge. To achieve compliance with Regulation 16.3(1), i.e. 'no defective SCSRs may be issued', would literally take one second. In turn, Regulation 16.2(3), 16.4(1) and 16.4(2) could be rephrased to reflect an'outcomes-bases' approach, or even dispensed with. In fact, the TTC on SCSRs would become redundant.

SCSRs, unlike any other breathing apparatus used in mining, are subjected to harsh environments on a daily basis. Because of the functional simplicity of chemical-based SCSRs, their reliability far exceeds that of their compressed oxygen counterparts that are infinitely more susceptible to malfunction. On the downside, functional status cannot be read off at a glance (despite moisture indicators) and this rather elementary distinction is the most important consideration in the argument for prescriptive elements of legislation. The argument for prescriptive legislation in respect of SCSRs, therefore, stems from the type of SCSR exhibiting the highest degree of reliability. Issues such as deliberate negligence or vandalism are complications but not fundamental to the debate.

The DME Guideline/COP mechanism, in exchange for 'outcomes-based' regulations, as has been suggested, is not a solution. The net effect is that the employer, in seeking compliance with Regulation 16.3(1), would have to satisfy the requirements of 'best practice' without the support of existing structures, i.e. the TTC-controlled industry-wide SCSR monitoring programme and all that it entails. Mines simply do not have the capacity to achieve this.

In summary: SCSR legislation in the South African mining industry is, in certain respects, in conflict with tripartite agreed regulatory norms. This state of affairs has been dictated solely by the idiosyncracies of the most reliable type of SCSR to emerge from an experience base of

nearly twenty years, i.e. the chemical-based (potassium superoxide) SCSR. Moreover, SCSRs are life-saving devices and in this regard the analogy to a parachute is appropriate: 'if it fails, you will never require its use again!'

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